AD-A153 232 APPLICATION OF FORWARD SCATTERING RENORMALIZATION TO SCATTERING IN TURBID MEDIA(U) VIRGINIA POLYTECHNIC INST AND STATE UNIV BLACKSBURG D A DE WOLF JAN 85 1/1

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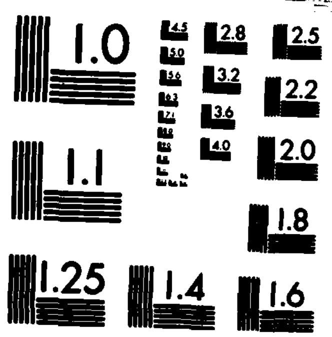

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APPLICATION OF FORWARD SCATTERING RENORMALIZATION TO SCATTERING IN TURBID MEDIA

FINAL REPORT

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JANUARY 1985

U.S. ARMY RESEARCH OFFICE

CONTRACT DAAG29-83-K-0164

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	ARO 20705.2-GS
2. GOVT ACCESSION NO.	N/A A153 232
3. RECIPIENT'S CATALOG NUMBER	N/A
4. TITLE (and Subtitle)	Application of Forward Scattering Renormalization to Scattering in Turbid Media
5. TYPE OF REPORT & PERIOD COVERED	Final Report 9/16/83 - 12/[illegible]/84
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	David A. de Wolf
8. CONTRACT OR GRANT NUMBER(s)	DAAG29-83-K-0164
9. PERFORMING ORGANIZATION NAME AND ADDRESS	Virginia Polytechnic Institute & State University Blacksburg, VA 24061
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS	U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709
12. REPORT DATE	
13. NUMBER OF PAGES	
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	
15. SECURITY CLASS. (of this report)	Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

NA

18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The conventional wave-integral equation in electromagnetic scattering, consisting of a sum of directly-received vacuum field plus a scattered field that sums weighted vacuum spherical waves from each scatterer, is replaced by one in which renormalized fields containing part of the multiply-scattered energy replace the vacuum fields. A first-order approximation in the renormalization equation is applied to bistatic (large-angle) scattering from weak random fluctuations of the permittivity in a distant volume, and to a sparse monodisperse distribution of isotropic particles to yield scattering → cont.

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cross sections with extended validity for the direct polarization. A similar correction is introduced for the cross polarization in the case of backscatter. Differences with other calculations are noted.

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Statement of the Problem:

The conventional analysis of electromagnetic scattering from a finite region of particles, or of a dielectric continuum, is based on an integral equation for the observed electromagnetic field. This integral equation follows from Maxwell's equations, and it has the form, $E = E_o + GVE$. Here, E_o is the unscattered field observed in the absence of any scattering medium, and the remaining term is a three-dimensional integral over the scattering volume. The field E is not known in the volume, yet it appears in the integral, hence an integral equation ensues. As the equation is usually intractable to further analysis, various approximations are made. One such approximation abandons knowledge of E inside V altogether and it replaces the integral equation by an integro-differential equation in the radiant intensity I. The ensuing radiative-transfer equation contains a number of approximations that are hard- though perhaps not impossible- to justify. This equation is not suitable for description for the interaction of EM waves in terms of the scattering amplitude of each scatterer. Another approach uses the $E = E_o + GVE$ equation, and transforms it into an expression for E by iteration. It is usually not possible to proceed beyond the first iteration, $E = E_o + GVE_o$, the single-scattering approximation. The goal of this effort has been to improve upon this approximation for large-angle scattering from collections of particles (turbid media), by use of a renormalization of the electric fields to include into a new E_o the effect of multiple forward scattering.

<u>Summary</u>:

i) The renormalized wave-integral equations have the form,

$$E = E_f + G_f V_b E,$$
$$E_f = E_o + G_o V_f E_f,$$
$$G_f = G_o + G_o V_f G_f.$$

The scattering potential V (given by the deviation of the electric permittivity in the volume from the surrounding free-space-like medium) is the sum of a tractable part V_f, which is responsible for small-angle scattering, and a remainder V_b. The two lower equations are the usual ones for plane and spherical waves, respectively, in a medium in which $V = V_f$. It is hypothesized that E_f and G_f can be obtained or approximated to a high degree from these equations. The first equation can then be a significant improvement over the unrenormalized integral equation, even after iteration. The work in this contract effort is based upon use of a first iteration, $E = E_f + G_f V_b E_f$.

ii) The first application of the above is to the bistatic large-angle scattering cross section from a slab of uniform turbulent medium. This situation corresponds to one in which one radar on the ground receives EM energy from another ground-based radar via scattering from clouds or other atmospheric aerosols. The "cross section" is simply a normalized form of the received power. The expression is in the form of a 3-D integral correction factor to the single-scattering approximation [see Eq. (25) of the article]. Evaluation of this factor is difficult, and work is still under way to reduce it to a tractable expression.

iii) Application of the above to scattering from a <u>turbid</u> medium is similar. However, particles can be coherent, incoherent, or quasi-coherent in their behavior as a medium. Various expressions ensue for each of these cases [Eqs. (32)-(35) of the article].

iv) It is also possible to extend an older double scattering estimate for the cross-polarized <u>backscatter</u> cross section. In this case at least <u>two</u> scatterings are required to induce cross polarization, hence double scattering is the lowest-order process. The new correction factor [Eq. (41) of the article] can be evaluated approximately for a spherical medium, and results are given [Eqs. (43)-(46) of the article].

LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED, AND PRESENTATIONS AT MEETINGS UNDER ARO SPONSORSHIP

1. "Renormalization of EM fields in application to large-angle scattering from randomly-continuous media and sparse particle distributions," to be published in IEEE Trans. on Antennas and Propagation.

2. "The renormalized wave-integral equation and applications," presented as a conference paper at
   a) IEEE-APS/USI Symposium, Boston, MA, June 25-29, 1984.
   b) CRDC Scientific Conference on Obscuration and Aerosol Research, Edgewood, MD, June 25-29, 1984.

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